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ABSTRACT

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Abstract

This paper summarizes two companion studies that were designed to investigate the impacts of an inquiry teaching method on Earth science students' achievement and attitudes toward Earth science in secondary schools. Subjects were 557 Earth science students (9th grade) enrolled in 14 Earth science classes. Two Earth science units including topics of astronomy and meteorology were developed and taught using the inquiry-oriented instructional model. The experimental group (n=284) received inquiry-oriented instruction while the control group (n=273) received a more traditional approach over an eight-week period. The dependent variables were measured through the use of (1) the *Earth Science Achievement Test* to assess Earth science students' achievement and (2) the *Attitudes toward Earth Science Inventory* to measure students' attitudes toward Earth science. Quantitative data were collected on students' pre- and post-treatment achievement and attitudes toward Earth science measures. Analysis of covariance revealed that (a) the inquiry-oriented instructional method produced significantly greater achievement among ninth grade Earth science students than the conventional teaching approach on both astronomy content (F=9.45, p<0.01) and meteorology content (F=8.41, p<0.01), and that (b) students in the experimental group developed significantly more positive attitudes toward Earth science than did those in the control group (F=9.07, p<0.01). In light of these two studies, it is therefore suggested that students can learn Earth science through the inquiry approach. In addition, these findings support the notion that effective instruction of Earth science, such as using inquiry-oriented instruction, should be proposed and implemented in secondary schools.

Key Words: inquiry, teaching methods, student attitudes, achievement, earth science

I. Introduction

According to the 1996 *National Science Education Standards* developed in the U.S. (NRC, 1996), "teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich student understanding of science" (p. 121). Inquiry-oriented instruction in the literature has been closely associated with other teaching methods, such as problem-solving, laboratory and cooperative learning, and discovery instruction. These methods are commonly referred to as the inquiry approach, which often places an emphasis on the extensive use of science process skills and independent thought.

Inquiry-oriented teaching practices have long been proposed and have prevailed in main-stream classrooms. Research findings on the comparative efficacy of inquiry vs. traditional instruction are conflicting. Many studies on the use of inquiry-oriented teaching approaches in typical secondary school classrooms have shown some positive effects on students' content-achievement (Chang & Barufaldi, in press; Ertepinar & Geban, 1996; Gabel, Rubba, & Franz, 1977; Geban, Askar, & Ozkan, 1992; Hall & McCurdy, 1990; Henkel, 1968; Mulopo & Fowler, 1987; Richardson & Renner, 1970; Russell & Chiappetta, 1981; Saunders & Shepardson, 1987), on content retention (Schneider & Renner, 1980), on laboratory skills or science process skills (Basaga, Geban, & Tekkaya, 1994; Mattheis & Nakayama, 1988;

Tobin & Capie, 1982), and on attitudes toward science or science activities (Gabel, Rubba, & Franz, 1977; Kyle, Bonnstetter, & Gadsden, 1988; Shepardson & Pizzini, 1993). On the other hand, some research has found that inquiry-oriented teaching strategies had no significant effect on the cognitive achievement of learners (Oliver, 1965; Orr, 1968), on the learning of science process skills or on cognitive development (Germann, 1989). Consequently, it is worthwhile to explore whether an inquiry-oriented instructional method will have any effects on Earth science students' learning outcomes at the secondary school level.

Earth science, which consists of geology, meteorology, astronomy, and oceanography, is one of the science subjects most relevant to students' everyday lives. Accordingly, the *National Science Education Standards* (NRC, 1996) embrace Earth and Space Science as one of the eight categories of content standards along with Physical Science and Life Science. Learning Earth science not only interests students in probing the mysteries of nature, but also can inspire students' concern for environmental issues, such as acid rain, destruction of the ozone layer, and groundwater pollution. Still and all, most of the aforementioned research studies on inquiry-oriented teaching strategies have emphasized life science, physics, and chemistry; only a few studies (for example, Chang & Barufaldi, in press; Russell & Chiappetta, 1981) have focused on Earth science content. Therefore, it is important to explore whether an inquiry-oriented instructional method will have positive effects on Earth science students' learning outcomes at the secondary school level.

Wise & Okey (1982) found the strongest effects for biology and *weakest for Earth science* in a meta-analysis of the effects of various teaching strategies on student achievement. Shymansky, Kyle, & Alport (1983) also reported a meta-analysis of the impact of the NSF-reform inquiry-oriented science curricula on student performance and found that the science curricula improved students' science achievement and process skills as well as attitudes toward science. Effect sizes were largest for biology and *weakest for Earth science* and chemistry. Shymansky, Hedges, & Woodworth (1990) further employed refined statistical procedures to re-synthesize the aforementioned research, and showed that the mean effects on four performance clusters (achievement, process skills, problem solving, and attitude) were significantly positive. It is, therefore, necessary and important to investigate the impacts of an inquiry-oriented instructional method on the achievement and attitudes of students with an emphasis on Earth science content.

Many researchers in the area of Earth science education have attempted to develop or employ inquiry-oriented instructional methods in the college. For example, Stefanich (1979) implemented an inquiry-oriented teaching method that encouraged students to gather data in order to interpret geological events. Starr (1995) also examined the effects of cooperative-learning strategies on geology achievement and students' attitudes toward science. The results indicated an improvement in achievement and enhancement of student attitudes toward science. While some previous research has shown that an inquiry-oriented instructional method can improve students' science process skills and content achievement, research on explicit teaching or traditional instruction has also revealed that student achievement is improved among certain kinds of students and for selected kinds of instructional objectives (Waxman, 1991). After reviewing research on inquiry-oriented teaching, Flick (1995) stated that: "Research on inquiry-oriented instruction has produced mixed results with the clearest effects occurring with more capable students, who have well trained teachers, and a supportive classroom environment" (p. 17). Accordingly, it is interesting and important to make a comparison between inquiry-oriented instruction and the traditional teaching method in terms of their effects on students' learning of Earth science content in typical classroom settings.

II. Purpose

The purpose of this paper was to detail two companion studies that were designed to investigate the impacts of an inquiry teaching method on ninth grade Earth science students' achievement and attitudes toward Earth science in secondary schools. The Phase I Study developed a teaching unit on astronomy and employed an inquiry-oriented instructional model to introduce this subject-matter. The Phase II Study utilized an identical teaching strategy but focused on meteorology.

III. Method

1. Subjects

The participants in these two studies were 557 ninth grade Earth science students enrolled in 14 Earth science classes and four volunteering Earth-science teachers who taught the above classes at four public junior high schools located in the northern region of Taiwan. These four junior high schools shared similar features, including similar student populations and

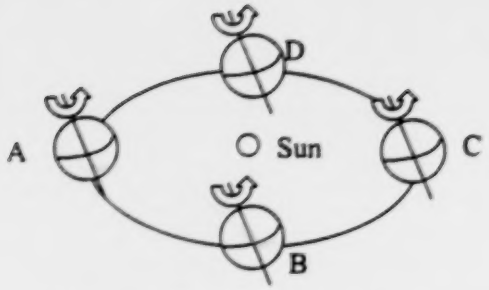

Fig. 1. Revolution of the Earth around the Sun.

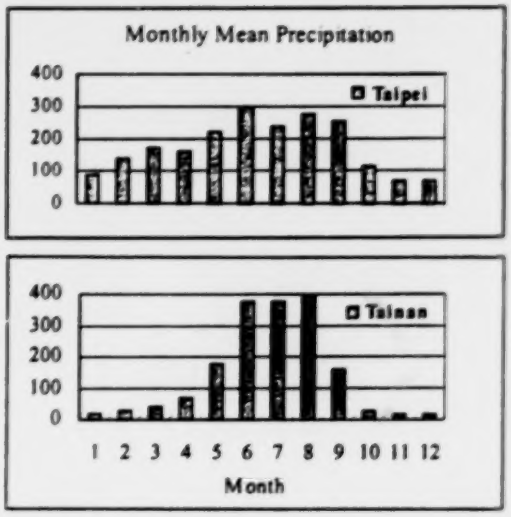

Fig. 2. Monthly mean precipitation in Taipei and Taiwan measured from 1958 through 1988.

school administration. Seven intact classes (n=284) were randomly assigned to the inquiry-oriented instruction group; the other seven classes (n=273) were randomly assigned to the traditional-lecture group. These students were typical secondary school students about 15 years of age; gender was equally distributed among the classes.

2. Instrument

The *Earth Science Achievement Test* was constructed and designed to measure Earth science content achievement and to assess knowledge, comprehensive, and application level objectives of the cognitive domain. The instrument consisted of selected or modified items from the following tests: (1) Taiwan Entrance Examination for Senior High School (TEESHS) – astronomy and meteorology topics, (2) Educational Progress in Earth Science Learning (EPESL), and (3) "Let's Review: Earth Science" (Deneck, 1995). The test items were all specifically related to textbook content and equally distributed among topics during the treatment periods. Content validity was established by a panel of experts, including four professors from the Department of Earth Sciences, National Taiwan Normal University. These experts checked the correspondence between the treatment and test item contents, and determined that the nature of the test items was strongly related to the important concepts introduced in the instruction.

After conducting item analysis, thirteen test items was selected and used as a pretest and twenty-six test items were included in the posttest for the Phase I Study (the Astronomy Content Study). The Cronbach alpha method was used to estimate the reliability coefficients of both the pretest and posttest. Reliability coefficients of 0.45 for the pretest and 0.82 for the posttest were reported for the Phase I Study. Two sample multiple-choice items were used in the posttest as follows:

Look at this diagram that shows revolution of the Earth around the sun. Then choose the answer that best fits each of the questions below (Fig. 1.):

(1) When the Earth moves to position C, what season is it in Taiwan? (1) spring (2) summer (3) autumn (4) winter.

(2) When the Earth moves from C to D, what kind of phenomena will happen in terms of the duration of daytime and nighttime in a day? (1) the same length (2) daytime is increasing (3) daytime is decreasing (4) nighttime is always longer than daytime.

As for the Phase II Study (the Meteorology Content Study), the pretest contained eight test items and the posttest consisted of twenty-four test items. Reliability coefficients (Cronbach alpha) of 0.40 for the pretest and 0.78 for the posttest were estimated for the Phase II Study. The following is an example of the test items used in the posttest of the Phase II Study:

The following two climate graphs represent monthly mean precipitation in Taipei and Tainan measured from 1958 through 1988. Please answer the following question based on your observation from the graphs (Fig. 2.).

Which one of the following descriptions is inaccurate? (1) Even the monthly mean precipitation for November and December in Taipei is the same, we should not infer that the length of rainy days is also the same during those two months. (2) The monthly

mean precipitation in June is more than that in August in Taipei, yet, it does not necessarily mean that this will happen every year. (3) Precipitation in Tainan occurs primarily from May through September. (4) Precipitation from April through September for both places accounts for less than half of their respective annual precipitation.

The instrument was further classified into three categories (factual, comprehensive, and integrated items) which correspond to Bloom's Taxonomy (1956) of knowledge (factual), comprehension and application (integrated) levels. The same panel of aforementioned experts, who were knowledgeable about the criteria of these categories, classified these items into three categories with high agreement. Consequently, the Phase I Study posttest included five items at the factual level, sixteen items at the comprehensive level, and five items at the integrated level. The Phase II Study posttest contained five items at the factual level, eleven items at the comprehensive level, and eight items constructed at the integrated level. The classification of test items aimed at investigating students' levels of understanding and achievement of Earth science content.

The *Attitudes toward Earth Science Inventory* consisted of 13 items designed to measure student' attitudes toward Earth science, including class participation, confidence level on the subject of Earth science, and learning interest in Earth science. This instrument (Appendix) was constructed by modifying survey items from an existing questionnaire: the *Attitude toward Biology Instrument* developed by Cheng and Yang (1995). Thirteen items were selected, modified and used as both a pretest and posttest to determine students' attitudes toward Earth science. Reliability was established through internal consistency. The Cronbach reliability coefficient was estimated to be 0.84 for the pretest and 0.85 for the posttest, respectively.

3. Treatment

It is important to distinguish between "inquiry-oriented" and "traditional" instruction in these two studies. Welch, Klopfer, Aikenhead & Robinson (1981) identified one major theme in science inquiry skills, which includes observing and interpreting data. The inquiry-oriented instructional method developed and employed in these two studies emphasized gathering and interpreting data by students in a cooperative-learning setting with the goal of improving students' learning of Earth science content. In addition, students also critically examined data for relationships by interpreting related data and then drawing conclusions. Another key feature of the inquiry-oriented teaching is cooperative learning, including small group discussion. Small group discussion is intended to increase interaction between students and the instructional materials. During group discussion, students clarify their own ideas and communicate with each other.

The inquiry-oriented instruction and instructional units employed in the Phase I Study focused on astronomy. The treatment consisted of an approximately four-week period of Earth science instruction. Student engagement was followed by gathering information, recording what had been observed, and interpreting data generated from hands-on activities and group discussion. During one hands-on activity, for example, students were first provided a diagram showing a series of stick shadows under the Sun on March 21 or 22 (spring equinox) in Taiwan. Students were then asked to project (or plot) different locations of the Sun on a mini transparent celestial sphere for that specific day. After observing the various locations of the Sun in a day, students were required to interpret data and make explanations through group discussion. This activity was also repeated for June 21 or 22 (summer solstice), September 22 or 23 (autumnal equinox), and December 21 or 22 (winter solstice) for further comparison and interpretation purpose. Class presentation of group-discussion results and teacher's discussions with students were followed by the teacher's explanation of the Earth-Sun system. The most important characteristics of the lessons were "student-centered" activities designed to encourage students to become more skillful in using science process skills and to create better understanding of Earth science concepts. The instructor served as a facilitator in the learning process.

Inquiry-oriented instruction in the Phase II Study also emphasized students' hands-on, minds-on activities, which involved gathering and recording data as well as interpreting data and their relationships. The characteristics of the inquiry-oriented instruction employed in this study are the same as those described in the Phase I Study, yet the instructional units focused on meteorology content. The treatment consisted of another four-week period of Earth science instruction, emphasizing inquiry. It is noted that the inquiry-oriented instruction proposed in these studies did not exclude the use of textbooks or other instructional materials but emphasized active search processes employed by students. It is also noted that the instructional materials prepared for the experimental group were also provided to the control group as a placebo

control.

The traditional instructional method in this study stressed direct lectures given by teachers, use of textbooks and other materials, and clear explanation of important concepts to students; occasional demonstrations and a review of the textbook topics were also included. The key feature of this "teacher-oriented" instruction was providing students with clear and detailed instructions and explanations. The teacher undertook the task of transferring science knowledge to students.

It is noted that each instruction group experienced the same topics (detailed below) and instructional time (eight weeks). The Earth science textbook copies for the eight-week period include the following units: Unit Nine - moisture and the atmosphere, convection currents, atmospheric pressure, air masses and weather fronts, weather map and weather, and climates; Unit Ten - the Earth-Sun system, the apparent movement of the Sun and the stars, the Earth's rotation and revolution, and seasons. Four weeks were allotted for Unit Nine, and four weeks were used for Unit Ten.

4. Design and Procedures

The experimental design for these two studies was a quasi-experimental non-equivalent control group design described by Campbell & Stanley (1966). Each instruction group participated in four weeks of instruction on astronomy (the Phase I Study), followed by another four weeks of instruction on meteorology (the Phase II Study). The *Earth Science Achievement Test* and the *Attitudes toward Earth Science Inventory* were administered to all the students at the beginning of the treatment as the pretests and were given again as the posttests at the conclusion of each respective instruction period. In addition, participating teachers were asked to write down a journal which described their personal perceptions toward the inquiry-oriented instruction and any problems they had encountered while implementing this specific teaching method in the main-stream classrooms. A number of variables were set constant in order to derive a statistical comparison between the experimental group and the control group. These variables were ninth grade Earth science students, similar school administration, the same participating teachers, and the same instructional content and duration in these two studies. The only variable for these studies was the inquiry-based instruction versus the traditional teaching method. The data were analyzed by employing analysis of covariance (ANCOVA) on posttest scores with the pretest as the covariate to determine any significant differences between the experimental group and the control group. ANCOVA was also conducted at the factual, comprehensive, and the integrated levels of the posttest measures to determine if there were significant differences between the two groups at these levels of understanding. The assumptions[1] of ANCOVA were first checked to insure that they were met in the analysis of covariance for these studies. Then these data were subjected to a 0.05 level of significant test. Tests of the assumptions for analysis of covariance (ANCOVA) and inferential statistical analyses were carried out using SPSS (Statistical Package for Social Sciences version 7.0).

Table 1. Summary of ANCOVA on Students' Achievement Scores for the Phase I Study

Posttest Level	Inquiry Groups Adjusted Mean (SD)	Traditional Groups Adjusted Mean (SD)	F
Factual Level	2.7(1.3)*	2.3(1.3)	8.44*
Comprehensive Level	9.0(3.6)*	8.1(3.6)	9.30*
Integrated Level	3.1(1.2)	3.0(1.3)	1.02
Total Items	14.7(5.3)*	13.4(5.4)	9.45*

*$p<0.01$

IV. Results

1. Phase I Study: Astronomy Content Study

Table 1 shows the results of ANCOVA and descriptive data analysis on students' achievement posttest scores. It is statistically indicated that subjects taught using the inquiry-oriented instructional method scored significantly higher than those taught using the traditional teaching method on Earth science content achievement (F=9.45, p<0.01) (total items). Additionally, significantly higher achievement scores for the experimental group were found at the factual (F=8.44, p<0.01) and comprehensive levels (F=9.30, p<0.01) of understandings. However, there were no significant gains in student achievement at the integrated level in the experimental group when compared with the control group (F=1.02, p>0.05).

[1] A conventional Barlet's test of homogeneity of variance indicated homogeneity among variance. Preliminary test for homogeneity of the regression slope performed significant test on interaction between the covariate and the variables. The results indicated that the assumption of parallelism of the regression slope was tenable because the F ratio yielded non significant values for all the variables.

Table 2. Summary of ANCOVA on Students' Achievement Scores for the Phase II Study

Posttest Level	Inquiry Groups Adjusted Mean (SD)	Traditional Groups Adjusted Mean (SD)	F
Factual Level	2.91(1.34)*	2.95(1.57)	0.11
Comprehensive Level	7.33(2.17)*	6.77(2.39)	9.63*
Integrated Level	3.74(1.84)	3.22(1.70)	13.44*
Total Items	14.07(4.40)*	13.05(4.87)	8.41*

*$p<0.01$

Table 3. Summary of ANCOVA on Students' Achievement Scores for the Phase II Study

Posttest Level	Inquiry Groups Adjusted Mean (SD)	Traditional Groups Adjusted Mean (SD)	F
Participation	1.81(2.30)*	1.34(2.35)	9.05*
Confidence	1.43(2.49)*	1.02(2.63)	5.52*
Learning Interest	1.51(1.60)	2.00(1.20)	1.04
Total Items	4.77(5.22)*	3.73(5.62)	9.07*

*$p<0.01$

2. Phase II Study: Meteorology Content Study

The results of ANCOVA and descriptive data analysis on students' meteorology achievement are summarized in Table 2. It is statistically shown that students exposed to the inquiry-oriented instructional method performed significantly better than those exposed to the more traditional approach (F=8.41, p <0.01) as shown in Table 2 (total items), especially at the comprehensive (F=9.63, p<0.01) and integrated levels (F=13.44, p<0.01). Nonetheless, no significant differences were found between the experimental groups and the control groups in the students' meteorology achievement at the factual level (F=0.11, p> 0.05).

3. Attitudes toward Earth Science

Descriptive data and the results of ANCOVA analysis of students' attitudes toward Earth science are shown in Table 3. It is statistically revealed that the inquiry-oriented instructional method did produce significantly more positive learning attitudes among Earth science students than did the traditional teaching method (F=9.07, p<0.01) (total items). Furthermore, the inquiry teaching approach significantly promoted positive attitudes toward Earth science among the experimental group at the participation (F=9.05, p<0. 01) and confidence levels (F=5.52, p<0.01). Still and all, no significant differences between the groups were found in terms of score gains at the learning interest level (F=1.04, p>0.05), as measured by *Attitudes Toward Earth Science Inventory*.

After analyzing data obtained from *Attitudes toward Earth Science* measure, we found that most students in the experimental group like the hands-on, investigative, and problem-solving activities in the Earth Science class. They also feel confident in solving Earth science problems and expressing themselves in the class.

4. Teachers' Perceptions toward the Treatment

Information obtained from participating teachers' journal writing revealed that most of the teachers appreciated and admired this type of instructional method. However, they admonished that this kind of teaching approach should be well prepared when employing it in the main-stream classrooms. Besides, selection of appropriate topics to introduce when using this kind of instructional method is also important. As one teacher stated that

> This kind of instruction (inquiry) is beneficial for students in terms of enhancing their thinking skills, however, implementing it requires more efforts and preparations.

V. Discussions and Implications

1. Content Achievement

After eight weeks of inquiry-oriented instruction, the experimental group had significantly higher science achievement scores than did the control group. It may be that pupils exposed to the treatment had the opportunity to observe, record, and interpret data on their own during hands-on investigative activities. Correspondingly, the basic and integrated science process skills emphasized in these studies might have helped the experimental group learn the Earth science content better compared to the control group. The results of these two companion studies are consistent with those of other studies, which showed that inquiry-oriented instruction produced positive outcomes in student science achievement (Bredderman, 1985; Ertepinar & Geban, 1996; Gabel, Rubba, & Franz, 1977; Geban, Askar, & Ozkan, 1992; Henkel, 1968; Mulopo & Fowler, 1987; Richardson & Renner, 1970; Russell & Chiappetta, 1981; Saunders & Shepardson, 1987). Furthermore, these two studies generate evidence to support the notion that the inquiry-oriented

approach is more effective in enhancing *learning of Earth science concepts* than is a more traditional teaching method.

The results of the Phase I Study at the integrated level showed no significant differences in the achievement of students between the experimental group and the control group. It may be that the nature of the integrated test items for Astronomy was difficult for students or that the number of integrated items (only five items at this level) was not sufficient to obtain a statistical distinction between the experimental and control groups.

The Phase II Study revealed no significant differences in the achievement of students at the factual level between the experimental group and the control group. Subjects taught using the inquiry-oriented instructional method did not outperform at the factual level those taught using the more traditional approach, perhaps because rote memorization aided performance at that level. On the other hand, the inquiry-group students did perform significantly better in terms of achievement for the upper-level items (the comprehensive and integrated levels) than did traditional-group students, apparently due to the emphasis of the instruction on science process skills and independent thought among students. The results of the Phase II Study also lend support to those of previous studies, which recorded improved science achievement among pupils at higher cognitive levels of Bloom's Taxonomy (Chang & Barufaldi, in press; Chiappetta & Russell, 1982; Ertepinar & Geban, 1996; Gabel, Rubba, & Franz, 1977; Geban, Askar, & Ozkan, 1992; Henkel, 1968; Mulopo & Fowler, 1987; Saunders & Shepardson, 1987).

The hands-on and minds-on activities used during the inquiry-oriented instruction seemed to enhance Earth science content achievement since they provided students with first-hand experience in doing science and opportunities to collect and interpret data and to make valid conclusions. Therefore, science teachers and educators should continue to promote inquiry-oriented instruction in the classroom. Moreover, students should be provided with opportunities to search and collect information, interpret and analyze data, draw conclusions, and share or communicate ideas at the secondary level.

2. Attitudes toward Earth Science

Students in the experimental group showed significantly more positive attitudes toward Earth science than did those in the control group. The results of these two studies are consistent with those of other studies (Gabel, Rubba, & Franz, 1977; Kyle, Bonnstetter, & Gadsden, 1988; Shepardson & Pizzini, 1993), which found that inquiry-oriented instruction or curriculum materials significantly improved attitudes toward science among students. Welch, Klopfer, Aikenhead, & Robinson (1981) stated that: "Thus, in an inquiry classroom there is a time for doing... a time for reflection... a time for feeling... and a time for assessment." (p. 35) It seems that inquiry activities might help students realize that they are doing and feeling real science, leading to more positive attitudes toward Earth science.

It is noted that the learning interest of these students not significantly different between two groups, perhaps because the students were not familiar with this type of instruction and were under tremendous stress due to an upcoming unified entrance examination. Nevertheless, participation and confidence levels were increased since the inquiry-oriented instruction provided the students with hands-on and minds-on activities and required them to work on their own rather than depend upon the teacher's explanations. The students assumed the role of "knowledge pursuer"; therefore, their attitude scores increased at the class participation and confidence levels of the affective domain.

VI. Conclusions

The inquiry-oriented instruction used in these two studies emphasize on student inquiry, interpretation of data, group discussions, and cooperative learning; these strategies might help develop students' higher mental skills, improve their attitudes toward Earth science, facilitate learning of Earth science concepts and, therefore, raise their levels of Earth science content achievement. Science education standards recently proposed in the U.S. state that all students should both learn about scientific inquiry and learn science through inquiry (NRC, 1996). The results of this pair of studies support this idea. It is, therefore, suggested that it can be beneficial for students to learn science through the inquiry approach. Likewise, the inquiry-oriented teaching method should be used as a primary vehicle to assist learning of Earth science in secondary schools. It is also believed by the researchers that effective instruction in Earth science, such as the inquiry-oriented instruction, should emphasize "student-centered activities" instead of "teacher-centered lectures" in secondary schools.

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Appendix

1. Earth science classes are: (1) very interesting (2) interesting (3) no opinion (4) not interesting (5) not interesting at all
2. My perception toward the "hands-on" activities in the class: (1) strongly like (2) like (3) no opinion (4) dislike (5) strongly dislike
3. I would rather listening to the teacher than doing activities in the class: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
4. If there is an Earth science class session today, I will feel: (1) strongly boring (2) boring (3) no opinion (4) interested (5) very interested
5. My perception toward the "investigative" and "problem-solving" activities in the class: (1) strongly like (2) like (3) no opinion (4) dislike (5) strongly dislike
6. I can learn a lot of knowledge in the Earth science class: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
7. I feel confident in the Earth science class: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
8. I can solve simple problems on astronomy and meteorology content: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
9. I have a lot of opportunities to fully express myself in the Earth science class: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
10. The "investigative" and "problem-solving" activities in the class are annoying: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
11. I am interested to learn more Earth science topics: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
12. I think that Earth science concepts are easy to understand: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree
13. I do not feel learning and thinking in the Earth science class: (1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree

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探究式教學法對國中學生地球科學學習成效與態度之影響

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摘　要

本文主旨在綜結兩個並行研究的成果。這兩項研究主要探討探究式教學法對中等學校學生的地球科學學習成就和其對地球科學態度之影響。共有來自十四個班級五百五十七位國中三年級的學生參與研究。研究中運用探究式教學法來教授天文及氣象兩個地球科學的單元。實驗組學生（n=284）接受八週的探究式教學模組，而控制組（n=273）則在同一時間內接受傳統式的教學法。研究中的兩項依變數採用下列兩種量表來測量：(1)地球科學學習成就測驗用來評估學生在地球科學上的學習成就；(2)地球科學態度量表用來探究學生對地球科學之觀感與態度。利用上述量表分別對學生實施前測及後測以取得量化之數據。根據共變數分析（ANCOVA）的結果顯示：(a)以探究爲基礎的教學法比傳統式教學法更顯著地增進學生在天文單元（F=9.45, p<0.01）以及氣象單元（F=8.41, p<0.01）的學習成就；(b)實驗組的學生比控制組的學生對地球科學有較顯著且正面的態度（F=9.07, p<0.01）。研究結果證明了學生可以經由探究的方式來學習地球科學。此外，研究之發現亦可支持以下的論點：這類具有成效之探究式教學法應該在中等學校地球科學課堂上全面的推展。

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